**Must-Knows: Unit 5 (Photosynthesis)**

Ms. Ottolini, AP Biology

**Test Format:** 22 multiple choice questions, 1 short answer question

***Directions:*** *To prepare for your upcoming test, please answer the following questions thoroughly and accurately on your answer sheet in the column titled “Your Answer Before Checking the Answer Key.” Then, check the answer key (posted on Ms. Ottolini’s wiki page). Finally, record any additions / changes to your answer in the column titled “Changes / Additions to Your Answer After Checking the Answer Key”*

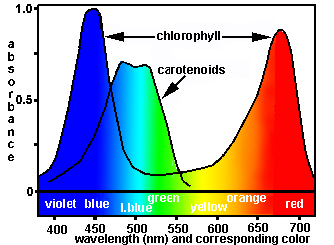
**Topic #1: Step 1 of Photosynthesis – The Light Reactions**

***Learning Target #1:***  I can explain how light energy is captured in the chloroplast and sent to the Calvin Cycle.

***Learning Target #2:***  I can identify the parts of the chloroplast and molecules involved in the Light Reactions.

1. What pigments are found in the thylakoid membranes? What is their role in the light reactions of photosynthesis?

Chlorophyll a and accessory pigments (ex: carotenoids) are found in the thylakoid membrane. Chlorophyll a absorbs mostly red and blue light. The light “excites” electrons within the chlorophyll and causes it to donate these electrons to the electron transport chain of the light reactions. Accessory pigments absorb different colors of light and maximize the amount / colors of light that can be used in photosynthesis.



1. What colors of light are most ABSORBED by chlorophyll a? What color of light is most REFLECTED by chlorophyll a?

Red and blue light are most absorbed by chlorophyll a. Green light is most reflected by chlorophyll a. (SEE GRAPH TO THE RIGHT)

1. What happens to water during the light reactions of photosynthesis?

Water is split using solar (sun) energy into electrons, H+ ions, and oxygen gas (O2). The electrons from water are used to replace the electrons lost by chlorophyll a, and oxygen gas is released.

1. What is the goal of cyclic electron flow?

In the Calvin cycle, more ATP is used than NADPH. However, non-cyclic electron flow produces equal amounts of ATP and NADPH. Therefore, photosynthesizing organisms must occasionally use a different process—cyclic electron flow—which makes ATP only.

1. What role do the electron transport chains in the thylakoid membrane play in the creation of a proton motive force? How is the proton motive force used?

Energy from electrons donated by chlorophyll is used by proteins in the thylakoid membrane to pump H+ ions from the stroma to the interior of the thylakoid (aka the thylakoid space or thylakoid lumen). This creates an H+ gradient, with a high concentration of H+ in the thylakoid space and a low concentration of H+ in the stroma. H+ “wants” to flow down its gradient back across the thylakoid membrane from the thylakoid space to the stroma. We call H+’s “desire” to flow down its gradient the “proton motive force.” The only way that H+ can flow back across the membrane is through the ATP synthase protein. As H+ ions flow through the ATP synthase protein, the protein turns and squishes ADP and P together to make ATP. (Note: ADP and P are just hanging out in the stroma of the chloroplast.)

**Topic #2: Step 2 of Photosynthesis – The Calvin Cycle**

***Learning Target #3:***  I can explain how energy from the Light Reactions is used in the Calvin Cycle to make glucose.

***Learning Target #4:***  I can identify the parts of the chloroplast and molecules involved in the Calvin Cycle.

1. What is the main goal of the Calvin cycle?

The main goal of the Calvin cycle is to use the energy from ATP and electrons carried by NADPH to convert carbon dioxide into 3-carbon sugar molecules which will be joined to form glucose.

1. Describe the relationship between the light reactions and the Calvin cycle.

ATP and NADPH are created during the light reactions and their energy is used during the Calvin cycle.

1. What are the reactants and products of the Calvin cycle?

Reactants = CO2, ATP, and NADPH

Products = 3-carbon sugars (which join to form glucose), ADP and Pi, and NADP+

1. Where in the chloroplast does the Calvin cycle occur?

The Calvin cycle occurs in the stroma (the fluid-filled space inside the inner membrane of the chloroplast).

**Topic #3: Exceptions to Normal Photosynthesis**

***Learning Target #5:***  I can discuss the purpose of C4 and CAM photosynthesis.

***Learning Target #6:***  I can compare and contrast C4 and CAM photosynthesis with normal (C3) photosynthesis.

1. What occurs during photorespiration? Why is this an issue for plants?

During photorespiration, Rubisco (an enzyme involved in converting CO2 to glucose) binds to oxygen gas instead of carbon dioxide. This prevents efficient production of glucose, since oxygen gas cannot be converted to glucose.

1. How do C4 plants minimize photorespiration?

In C4 plants, the part of the Calvin cycle that uses Rubisco occurs in the bundle-sheath cells, which are isolated from oxygen. Thus, Rubisco will bind to carbon dioxide, not oxygen.

1. How do CAM plants minimize photorespiration? Why do CAM plants keep their stomata closed during the daytime?

CAM plants take in carbon dioxide through their stomata at night. They store this carbon dioxide in the vacuole and release it during the day when the stomata are closed in the space surrounding the enzyme Rubisco. By releasing high concentrations of carbon dioxide around Rubisco, these plants ensure that Rubisco fixes mostly carbon dioxide, not oxygen gas.

**Topic #4: Comparing Photosynthesis with Celluar Respiration**

***Learning Target #7:***  I can compare and contrast the overall chemical equations for photosynthesis and cellular respiration and describe how these processes work together as a cycle.

***Learning Target #8:***  I can identify the types of organisms that use photosynthesis, cellular respiration, or both.

***Learning Target #9:***  I can compare and contrast the purpose and process of the electron transport chain in chloroplasts and mitochondria.

1. Why are photosynthesis and cellular respiration often thought of as a cycle? Write out the full, balanced chemical equation for each process and compare them.

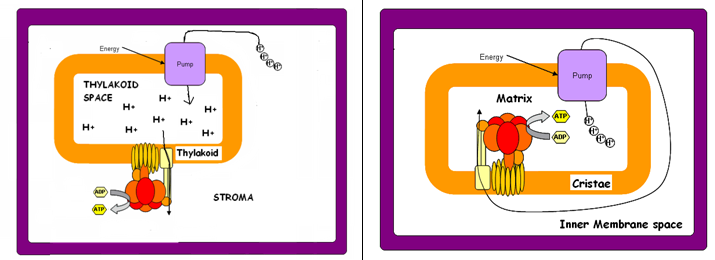
The products of photosynthesis are the reactants of cell respiration and vice versa.

|  |  |
| --- | --- |
| **Process** | **Equation** |
| Photosynthesis | 6CO2 + 6H2O + light energy 🡪 C6H12O6 + 6O2 |
| Cellular Respiration | C6H12O6 + 6O2 → 6 CO2 + 6 H2O + ATP |

1. What types of organisms have chloroplasts? What types of organisms have mitochondria?

Eukaryotic autotrophic organisms have chloroplasts (i.e. plants and certain protists). All eukaryotic organisms have mitochondria (i.e. animals, plants, fungi, and protists) because all organisms must convert glucose to ATP, a more usable form of energy for the cell.

1. Compare / contrast the electron transport chain in the mitochondrion vs. chloroplast in terms of the electron carriers used to “drop off” electrons, the direction of H+ pumping, the creation of an electrochemical gradient, the synthesis of ATP, the final electron acceptor, etc. How are they similar? How are they different? You can use the diagram below to assist you.



In mitochondria, the molecule that donates electrons to the electron transport chain is NADH (or FADH2). In chloroplasts, the molecule that donates electrons to the electron transport chain is chlorophyll, and these electrons are replaced by electrons from water.

In mitochondria, hydrogen ions are pumped from the matrix to the intermembrane space. They then flow back down their gradient from the intermembrane space to the matrix through ATP synthase. ATP synthase turns, causing ADP and Pi to squish together and form ATP.

In chloroplasts, hydrogen ions are pumped from the stroma to the thylakoid space. They then flow back down their gradient from the thylakoid space to the stroma through ATP synthase. ATP synthase turns, causing ADP and Pi to squish together and form ATP.

The final electron acceptor for the electron transport chain in the mitochondrion is oxygen gas. The final electron acceptor for the electron transport chain in the chloroplast is NADP+.

***Summary:***

Similarities = creation of a proton (hydrogen ion) gradient, use of ATP synthase

Differences = Electron donors and acceptors, direction H+ ions are pumped

***\*\*\*Note: On your test, there will be three “Science Skills” multiple choice questions where you will be asked to analyze a graph or chart showing photosynthesis data. Though the questions are related to photosynthesis data, you really only need to use critical thinking skills to find the answers.\*\*\****